

Institute for Clean Energy Technology

A tradition of research excellence in the
Bagley College of Engineering at Mississippi
State University since 1976.

Glenn Steele Interim Director

ICET



Mississippi State
UNIVERSITY

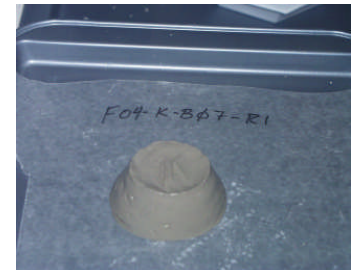
ICET Vision



- MISSION - Improve our customer's performance through characterization of processes, systems, or products
- VISION - Achieve global recognition as innovative, responsive and flexible organization solving challenging problems requiring characterization of the performance of processes or products, especially in the energy and environmental fields
- APPROACH
 - Apply unique blend of scientific and engineering expertise
 - Stress teamwork and collaboration, inside and outside MSU
 - Utilize state-of-the-art instrumentation and adaptable test facilities
 - Bring to bear resources of "full-service" research university
 - Provide non-traditional educational experiences to students

Support for DOE Environmental Management

- Projects supporting remediation of the nuclear waste legacy
 - Waste Processing
 - Soil and Groundwater
 - Closure
- The major objectives of the MSU ICET work are:
 - to provide “decision-quality” data so that site personnel have the best possible information available to make technical decisions relating to either closure or acceleration.
 - to facilitate beneficial interactions between technology developers, users, and stake-holders (particularly regulators).
- Example
 - The Fernald site (near Cincinnati) used to be involved in processing uranium ore. Silos closure expected by 2006
 - Developed new grout formulations that led to baseline elimination of 2000 containers (savings to project > \$50 M)
 - Developed “hot” / “cold” test loops at ICET for troubleshooting
 - Evaluated and tested wastewater treatment methods
 - Support full-scale processing of Silos waste at Fernald



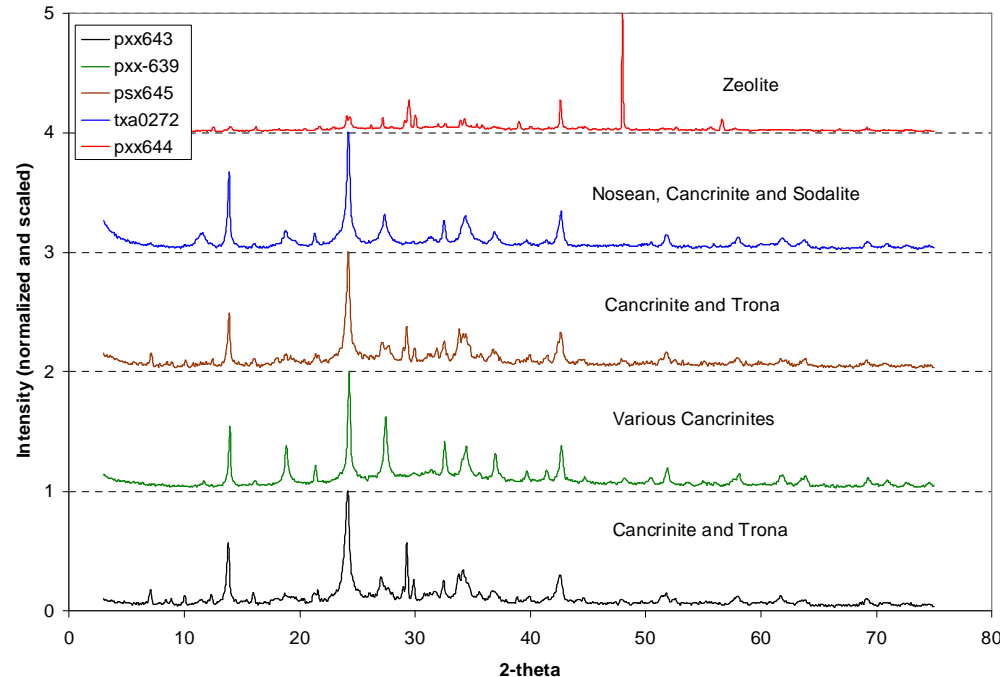
Current DOE Environmental Management Project Tasks



- Task 1: Modeling and Experimental Support for High-level SRS Salt Disposition Alternatives
- Task 2: Direct analysis of SRAT (slurry receipt and adjustment tank) contents
- Task 3 SRS Saltstone Process Studies
- Task 4: Evaluation of HEPA Filter Performance under Upset Conditions
- Task 5: C Tank Farm Chemistry Neutral Network Development
- Task 6: Long-Term Monitoring of Selected Heavy Metal and Radionuclide Contaminants and Application of Phytoremediation
- Task 7 Bioavailability Studies of Heavy Metals and Radionuclides Contaminants in Ecosystems of Selected DOE Sites
- Task 8 In-Tank Characterization for Closure of Hanford Waste Tanks

Modeling and Experimental Support for High-level SRS Salt Disposition Alternatives - J. S. Lindner and L. T. Smith

- Work is aimed at thermodynamic evaluations of the SRS caustic side solvent extraction (CSSX) process and the evaluation of downstream impacts of aluminum leaching operations.

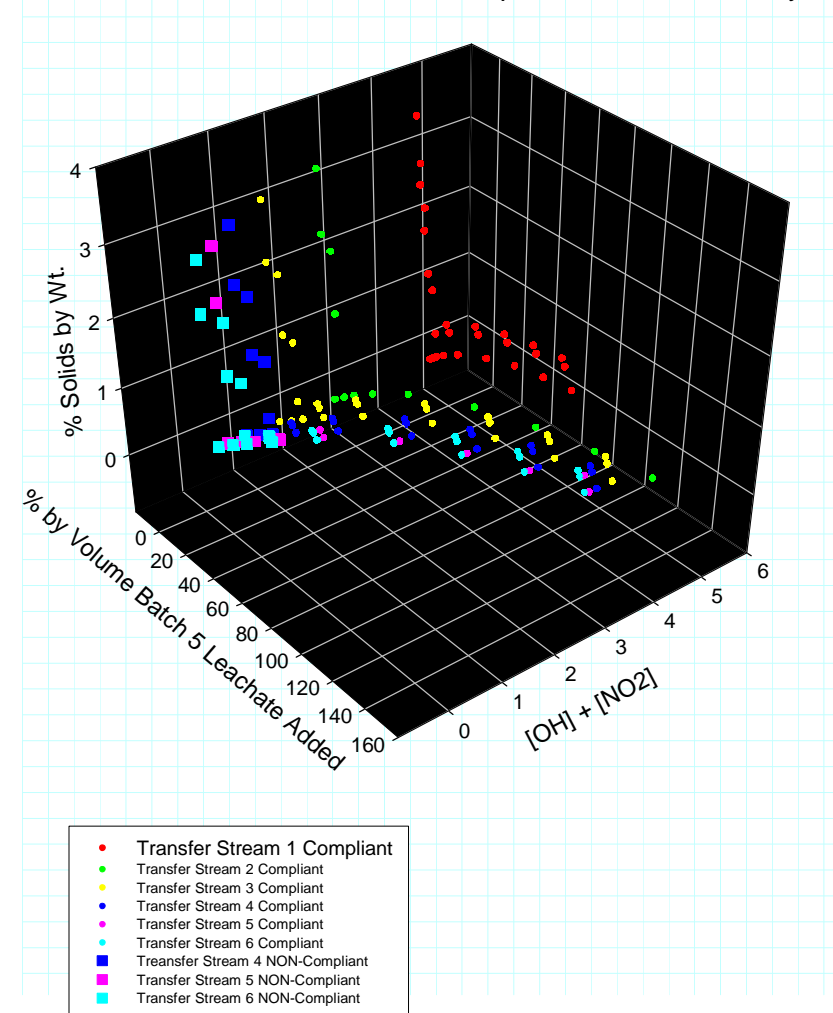


X-ray diffraction analysis of solids from operation of the CSSX pilot-scale facility indicated the presence of cancrinite and sodalite. These materials form difficult to remove scales within the process contactors. Development of limits for Al and Si are expected to minimize or eliminate solids formation

Modeling and Experimental Support for High-level SRS Salt Disposition Alternatives - J. S. Lindner and L. T. Smith

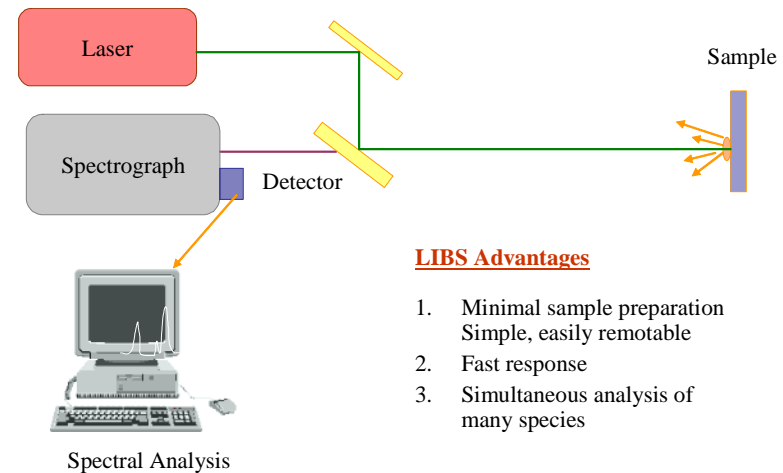
- Leaching of sludge destined for the Defense Waste Processing Facility results in an aqueous phase high in Al and OH. The ability to blend this stream with other process streams from saltcake dissolution and then route the resulting compositions to the Salt Waste Processing Facility allows for separation of high and low activity waste.
- The figure illustrates a potential operating envelope for the dissolution of saltcake in Tank 25F and blending with Batch 5 leachate. The curves represent different stages of saltcake dissolution. The idea is to maintain $[\text{OH}] + [\text{NO}_2]$ above 1.2M and minimize solids formation

Plot Transfer Streams Corrosion Compliance and % Solids by Wt.



Direct analysis of SRAT (slurry receipt and adjustment tank) contents - J. P Singh

- This task focuses on investigating methods to increase production at the DWPF using Laser Induced Breakdown Spectroscopy (LIBS). The probe beam and the emission spectrum can be routed to a controlled area using fiber optics.



- Two subtasks are examining the development of LIBS as an inlet feed monitor
 - Evaluation of select slurry constituents
 - Analysis of surrogate PuO_2 residues

Direct analysis of SRAT (slurry receipt and adjustment tank) contents J. P Singh



- Evaluation of select slurry constituents
 - Slurry Mix Evaporator (SME) product (a slurry containing both the sludge + frit) Calibration
 - Study the effect of slurry sample particle size on LIBS measurements
 - Compare LIBS data of pellet recorded with single pulse with DP configurations
- Analysis of surrogate PuO_2 residues
 - The accuracy and precision of the LIBS results from the CeO_2 batch in pellet form with polyvinyl alcohol (PVA) binder, without binder and in powder form are generally better than 5% for the major elements and better than 10% for most of the minor elements.
- Planned Work
 - Field Demonstration at SRNL

SRS Saltstone Process Studies R. Palmer

- Pilot-scale studies of SRS Saltstone Re-formulations
- DWPF Batch 5 contains higher loadings of Al than previous batches.
- Caustic leaching of the sludge will generate a stream rich in Al which is to be processed as saltstone.
- This has raised concerns about excess heat of hydration which may create problems for the processing and storage of the waste form.
- Different formulations are under investigation



Previous work for the INEL Calcine Disposition Project focused on the down-selection for a specific waste form.

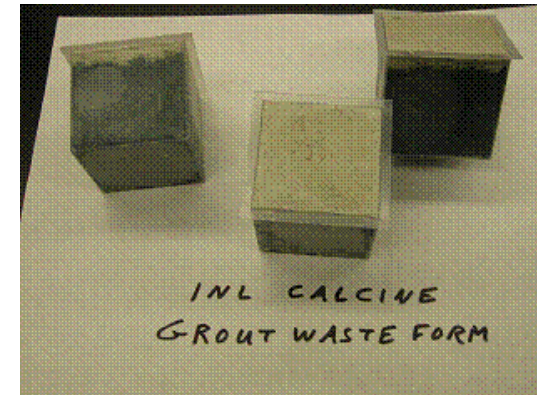
Three waste forms examined included

Iron phosphate ceramic

Hydroceramic cement

Grout

Grout was selected and a pilot plant was constructed and the grout process was successfully demonstrated for INL calcine



SRS Saltstone Process Studies R. Palmer



- Current Workscope
- Collaboration with SRS on Saltstone
- Establish protocol for making small (lab-scale) batches
- Design and build an adiabatic calorimeter
- Measure heat of hydration of reference Saltstone and new formulations
- Select new formulations for pilot-scale tests
- Perform pilot-scale experiments
- Transfer of data package to SRS

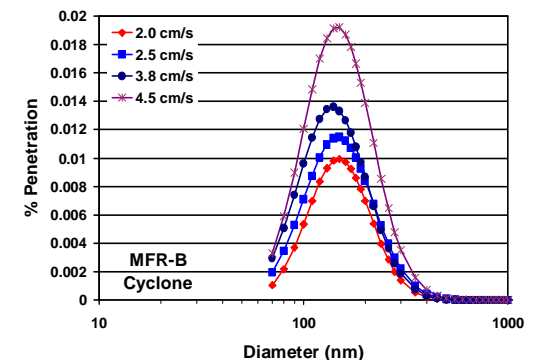
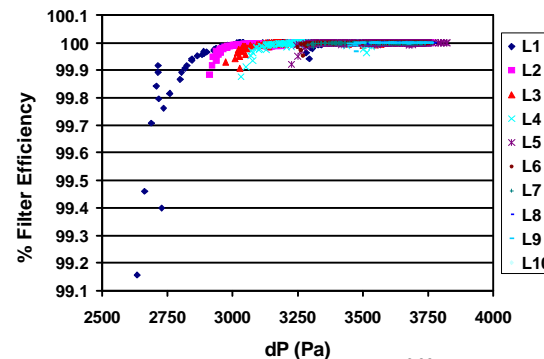
Evaluation of HEPA Filter Performance under Upset Conditions - C. A. Waggoner and R. Arunkumar

- Evaluation of Traditional HEPA and Regenerable Filters to Influence Regulatory Codes and Standards
- Filter Efficiency
- Lifetime
- Variable Source Term Performance Measurements
- Reduce risks and costs associated with filter use - determine failure modes and evaluate performance of traditional HEPA and regenerable filters

Filtration media velocity > 5 ft./min. does not result in filter efficiency < 99.97 % or unacceptable ultrafine emissions

Similarity in mass loading curve shape indicates degree of surface vs. depth loading is constant for velocities probed

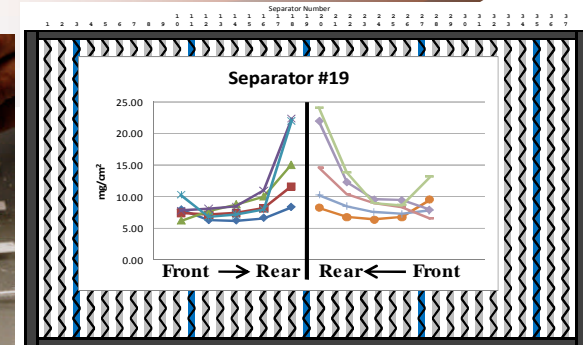
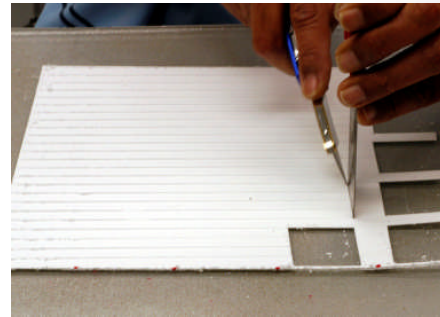
Ceramic membrane regenerable filters exhibit good efficiency and mass capture vs. dP gain - some concerns regarding air back-pulse “regenerability”



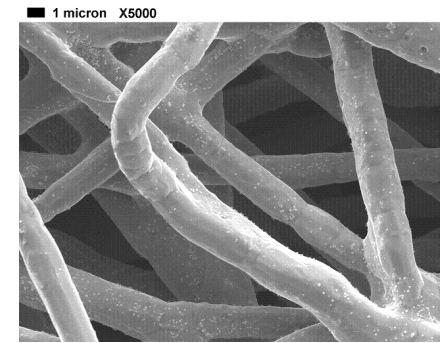
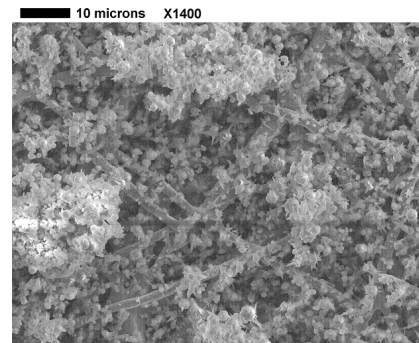
Evaluation of HEPA Filter Performance under Upset Conditions - C. A. Waggoner and R. Arunkumar

2008 Current Workscope

- Continuation of Media Velocity Testing
 - Finalize filter “autopsies” started in 2007
 - Identify Filter Loading Patterns for Validation/Incorporation into Models
- Peer reviewed publications and recommendations to codes and standards committees
 - ASME - Committee on Nuclear Air and Gas Treatment (CONAGT)
 - ASME FI (Metal Filters) Working Group



AG-1 HEPA Filters loaded at various media velocities with different aerosol particle size distributions are being autopsied to determine the accuracy of filter loading models. These studies will enhance the ability to design filtration systems with respect to filter lifetime and performance.



Microphotographs of sintered metal fiber media that has been loaded with tank sludge surrogate material and wet cleaned. Section FI of the AG-1 Standard will facilitate use of metal media filters in nuclear applications.

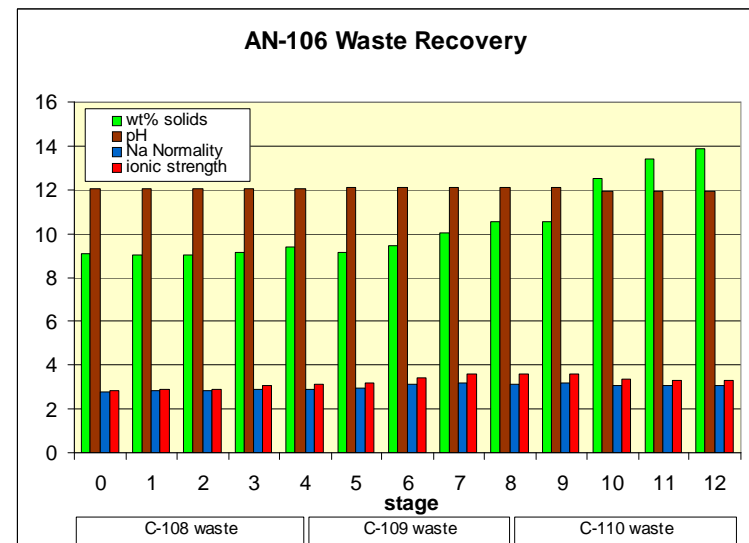
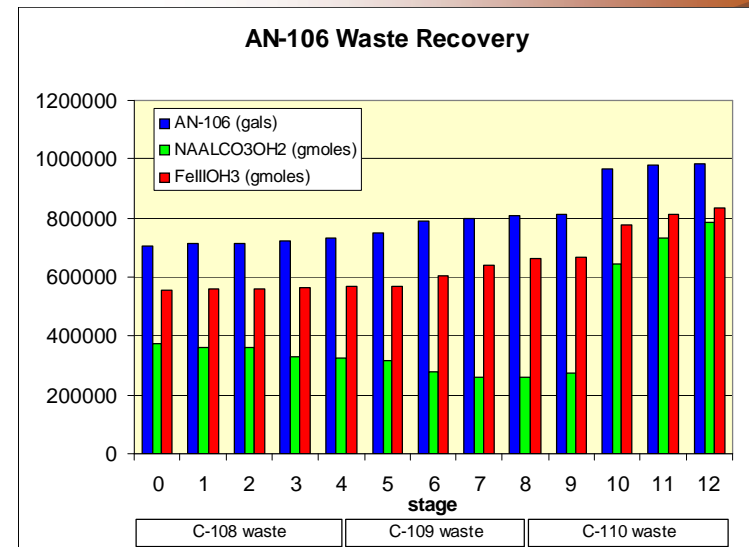
C tank farm chemistry neutral network development - J. S. Lindner, J. C. Luthe, and L Pearson

- Incorporate equilibrium chemistry in HTWOS (Hanford Tank Waste Operations Simulator) for C-tank transfers, in place of wash/leach factors, to predict process stream parameters, e.g. solid formation.
- Use ANN (Artificial Neural Network) model in place of explicit computations.
- Develop ESP simulation model of the tank recovery process to approximate the process chemistry streams in the sections of HTWOS where ANN will be used.
- Create ANN: train with transfer/mixing chemistry results.
- C-Farm retrievals to be done using the modified sluicing with recycle (MSwR) method of waste retrieval and mobile retrieval system (MRS).
- MSwR consists of four basic stages based on 1) the amount of waste retrieved and 2) the percent of entrained solids attained

Stage	Ending tank waste volume (gal)	Retrieved waste volume (gal)	Solids entrainment (vol%)
1		5400	1.0
2	20,000		6.0
3	8,000		2.0
4	2,693		0.5

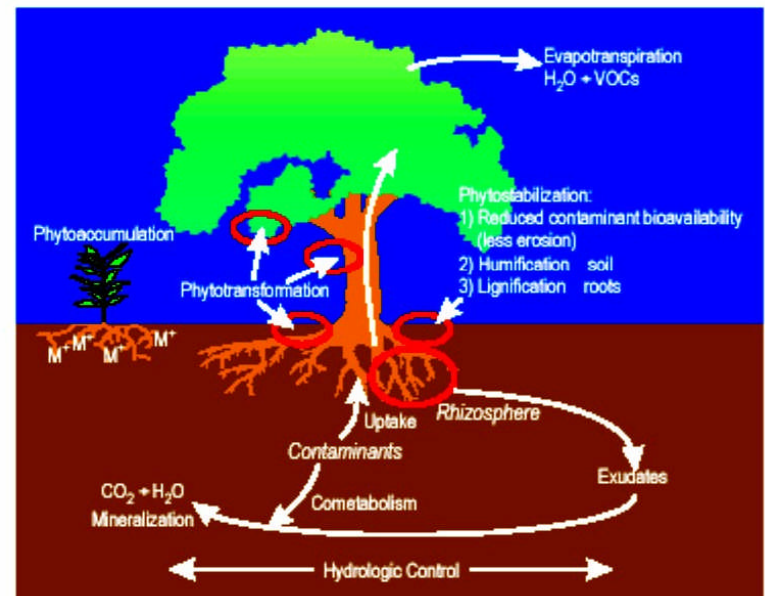
C tank farm chemistry neutral network development - J. S. Lindner, J. C. Luthe, and L Pearson

- Figures provide predicted results of the changes in the double shell destination tank AN-106 during the retrieval of C-108, C-109, and C-110
- Expanded training sets are being generated through automation (scripting) of the thermodynamic software.
- An evaluation of the retrieval schedule, including source and destination tanks is expected from the ANN.
 - Allow for different retrieval scenarios.
 - Schedule optimization.
 - Straightforward approach for evaluating the use of ANN's in the HTWOS model as chemistry is not as complex as saltcake retrieval or evaporation.



Long-Term Monitoring of Selected Heavy Metal and Radionuclide Contaminants and Application of Phytoremediation - Y. Su

- Applicable DOE Needs:
 - 1). Develop Integrated Methods for Long-Term Monitoring, i.e., sentinels and biomarkers.
 - 2). Groundwater and Soil Remediation.
- DOE Sites: Oak Ridge, Savannah River
- **Phytoremediation:** Use of plants to degrade, extract, contain, or immobilize contaminants from soil and subsurface water.
- **Contaminants studied:** Hg, Cd, Zn, Cu, As, Cr, Cs, Sr, U.
- **Plant species:** Fern, grass, mustard, barley.

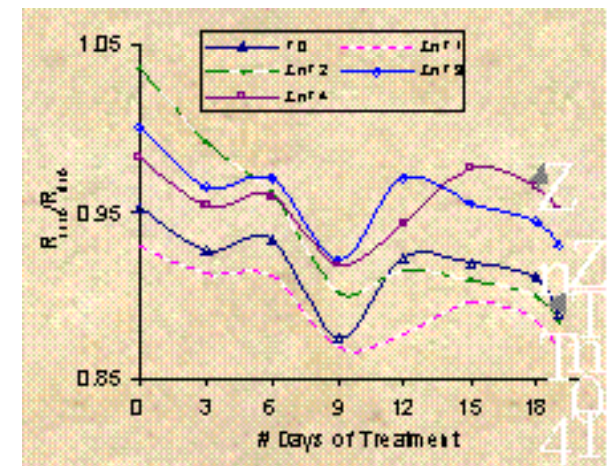


Long-Term Monitoring of Selected Heavy Metal and Radionuclide Contaminants and Application of Phytoremediation - Y. Su

- Long-term-monitoring: combination of remote sensing and bio-sentinel and biomarkers (i.e., vegetation)
- Correlations between metal accumulation, physiological changes, and spectral reflectance.
- Search for metal - related spectral signatures.

Summary of Findings

- Studied the phytotoxicity, phytoextraction of heavy metal and radionuclide contaminants, such as Hg, Cd, Zn, Cu, As, Cr, Cs, Sr, U, etc. in soil and water with various plant species.
- Correlation between metal accumulation, internal structural change, and canopy spectral reflectance are studied. A unique metal-related spectral index was developed and applied with other remote sensing indices.
- 14 papers published in refereed international journals, more than 20 presentations at DOE and other national/international conferences in the past few years

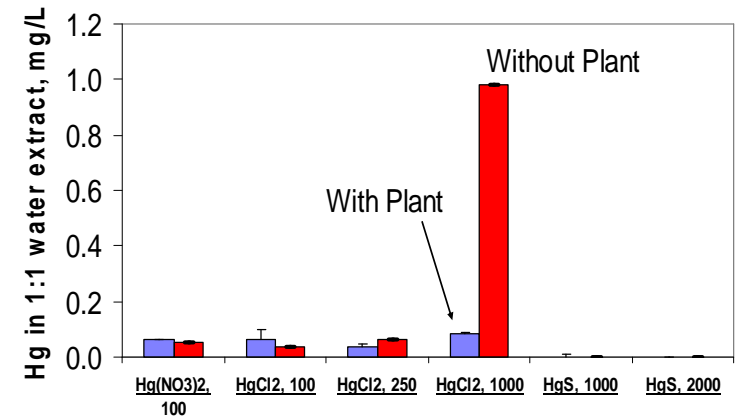


Ratio Index for
Metal Accumulation

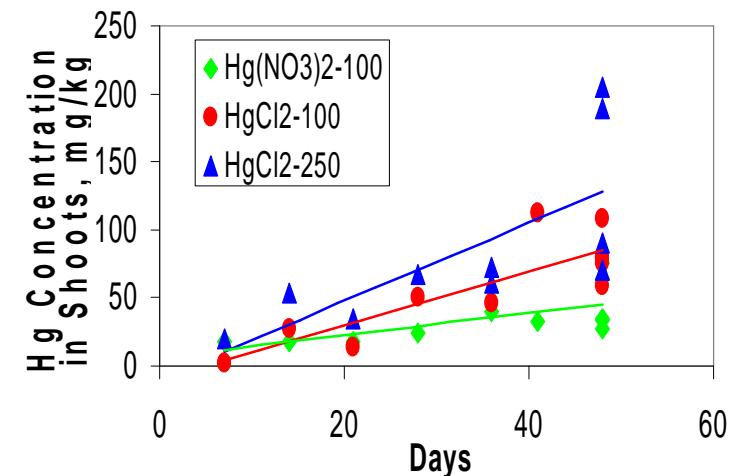
Bioavailability Studies of Heavy Metals and Radionuclides Contaminants in Ecosystems of Selected DOE Sites

- F. X. Han

- Accelerate Y-12 and balance-of-site closure (develop process for mercury removal, and methods to determine “how clean is clean enough”) 100,000 - 200,000 lbs of elemental mercury has been lost to the ground at Oak Ridge
- Phytoremediation: a technology that uses various plants via absorption to degrade, extract, contain, or immobilize contaminants (heavy metals) from soil and water.
- Construct mercury test bed
- Determine bio-availability of mercury to set “how clean is clean enough”
- Select “best” plant
- Field test at ORNL FY'06



Uptake of mercury into Chinese brake fern

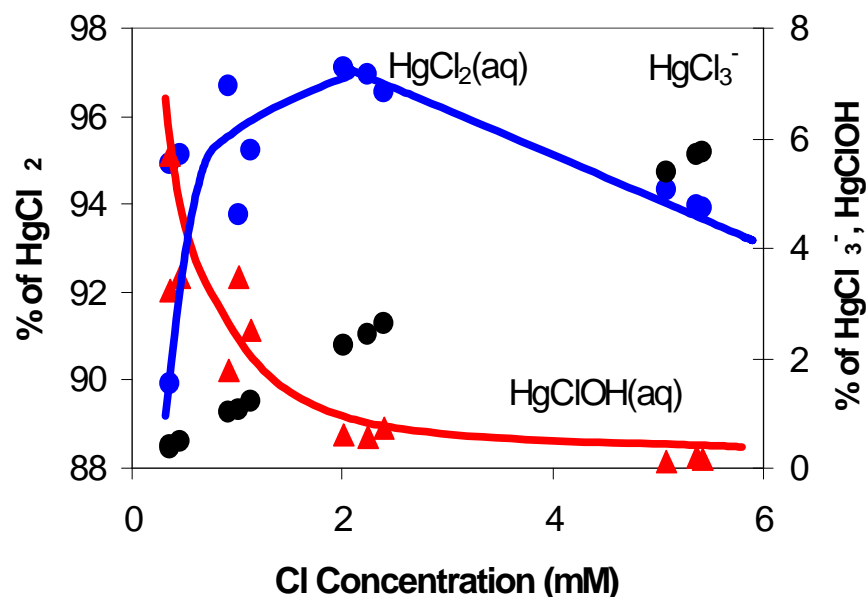
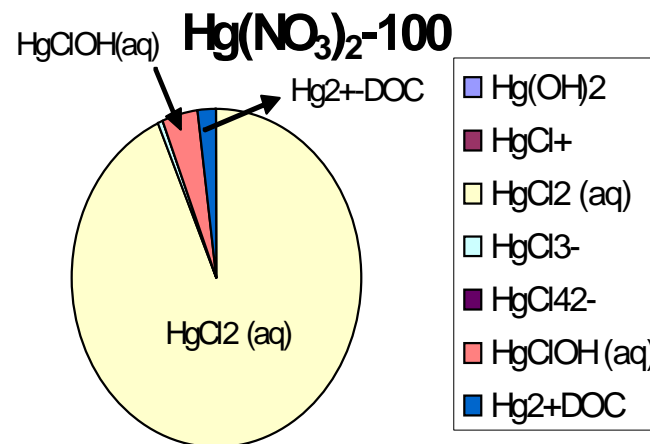


Bioavailability Studies of Heavy Metals and Radionuclides Contaminants in Ecosystems of Selected DOE Sites

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Hg speciation in soil solution

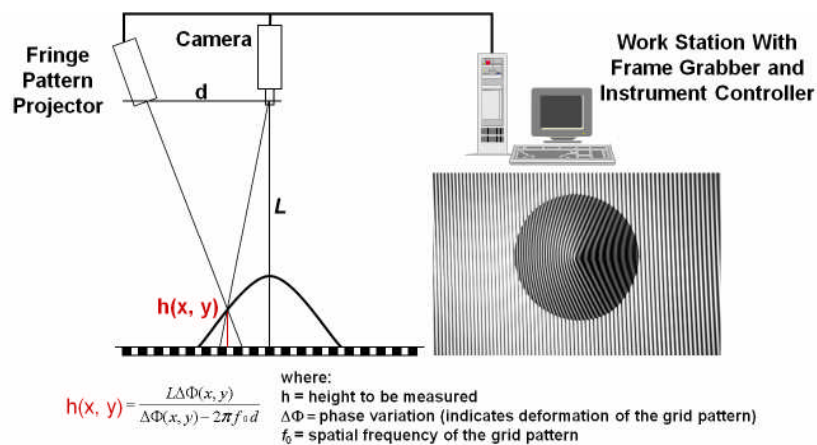
- Mercury chloride complex is the predominant mercury species in soil solution of Oak Ridge soil.
- Cl concentration strongly affects distribution of Hg chlorine complexes
- Additional soil samples from different ORNL sites will be collected and evaluated



In-Tank Characterization for Closure of Hanford Waste Tanks

D. L. Monts

Applicable Site Needs In situ quantitative determination of residual tank waste volume for closure of Hanford waste tanks.



Fourier Transform Profilometry (FTP) is an optical full-field 3-D surface measurement triangulation technique. A grid pattern is projected upon a target surface and its deformation is determined by image analysis. The height profile is derived from the grid pattern distortion relative to reference image pattern



The technology has been previously demonstrated for evaluating pit corrosion on pool walls at the Oak Ridge National Laboratory Research Reactor Facility

In-Tank Characterization for Closure of Hanford Waste Tanks

D. L. Monts

- Completed first stage of FTP performance evaluation under simulated Hanford waste tank conditions.
- Determined that FTP results are relatively insensitive to evaluator.
- Completion of multi-stage FTP performance evaluation under simulated waste tank conditions.
- Work in Progress
 - Demonstration at ICET of FTP probe prototype under simulated waste tank deployment conditions.
- Work Planned
 - Design review
 - Demonstration at Hanford Cold Test Facility (CTF).

